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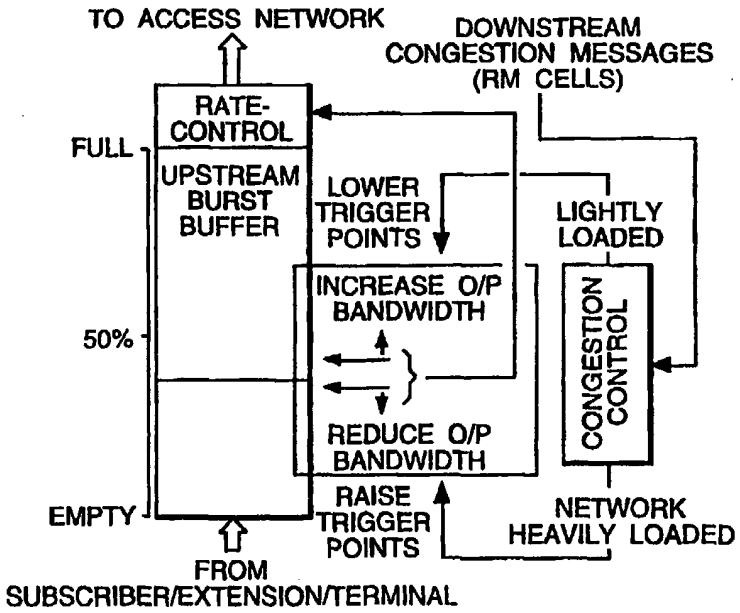

(57) Abstract

A switched Asynchronous Transfer Mode network has three buffers at the input of the network which hold ATM cells for Constant Bit-Rate traffic, Sustainable Cell-Rate traffic and Available Bit-Rate traffic respectively, the latter two buffers having a lower controlled rate of cell egress than the first of the buffers, the rates of egress being controlled in response to the relationship of the contents of the buffers to upper and lower specified values.

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CONGESTION AVOIDANCE

The existing Public Switched Telephone Network (PSTN) carries voice services over constant-bit-rate channels which are committed for the duration of a call; therefore congestion may only occur at call set-up.

The existing Packet Switched Public Data Network (PSPDN) carries data in packets over virtual-channels which are statistically-multiplexed onto bearers. Congestion may occur at any time but the integrity of the data is protected by the integral High Level Data Control (HDLC) protocol which operates link-by-link.

The PSTN is inefficient in carrying data because the channel occupies bandwidth whether or not it carries information.

The PSPDN is not able to carry a voice dialogue because of the delay-variation introduced by statistical-multiplexing and the integral HDLC protocol.

An Asynchronous Transfer Mode (ATM) network is required to carry a mixture of the two traffic types described above; its traffic characteristics and features are therefore fundamentally different from either the PSTN or the PSPDN. The present invention is to identify and provide solutions for the handling of the different traffic classes in the access layer of an ATM infrastructure.

According to the present invention there is provided a switched Asynchronous Transfer

Mode (ATM) network comprising a plurality of switches and having at or adjacent to the input of the network a set of three first-in first-out (FIFO) buffers for receiving calls comprising ATM traffic, the buffers being for Constant Bit-Rate (CBR) traffic, Sustainable Cell-Rate (SCR) traffic and Available Bit-Rate (ABR) traffic forms of ATM traffic respectively, the output rates from the SCR and ABR buffers being controlled by increasing the output rate of a buffer by a small increment when the contents of the buffer exceed an upper specified value and reducing the output rate by a small increment when the contents of the buffer are less than a lower specified value.

The present invention will now be described by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows a block diagram illustrating an ATM Access Upstream Buffer for use in the present invention;

Figure 2 shows a block diagram illustrating Traffic Shaping and Congestion Avoidance as carried out in the present invention; and

Figure 3 shows a block diagram illustrating the ATM Flow-Control Loop of the present invention.

The International Telecommunications Union (ITU) Study Group 13 recognises three ATM traffic classes; these are:-

* Constant Bit-Rate (CBR) (class A)

  Principally to carry voice.

* Sustainable Cell-Rate (SCR) (class B)

  Principally to carry variable bit-rate video.

* Available Bit-Rate (ABR) (class Y)

  Used to carry data.

One of these traffic classes is associated with each virtual-channel at set-up time.

The SCR and ABR traffic-classes together are defined as bursty; that is, the instantaneous bandwith occupied by a virtual-channel (VC) is continuously varying.

The mean bandwidth of a bursty VC is substantially lower than the peak bandwidth. An ATM switch will provide a multiplexing function at its output ports including a memory buffer which allows the multiple sources to queue for access to the bearer, thus smoothing the traffic flow. When many bursty channels are carried in one bearer the probability of coincidence of peaks resulting in overflow of the finite memory of the buffer queue is relatively low. Thus, it is possible to dimension the network based on virtual-channel bandwidths approaching the mean and hence carry many more channels than would have been the case if dimensioning was based on peak bandwidth; known as the "statistical-gain" of the system.

The quality-of-service provided, in terms of cell-loss probability, is dependent upon the maximum permitted peak channel bandwidth (the lower the channel bandwidth the larger the number of channels carried and hence the lower the standard-deviation from the statistical mean for the bearer), the size of the memory buffer in the switch (the larger the buffer the longer the period of burst integration) and the "burstiness" of the traffic flow entering the switch.

Limiting the VC peak bandwidth is a function of the system control and VC policing functions provided and switch memory-buffers need to be relatively small both to minimise cost and avoid excessive delay. Bursty traffic can, however, be "conditioned" in the access network in order to achieve a smoother traffic flow before entering the switching network. A large memory buffer positioned adjacent to the point of entry to the access network. All bursty traffic (SCR and ABR classes) is directed via this buffer. However, SCR traffic - more sensitive to delay and delay-variation than ABR traffic - is given the higher priority for egress from the buffer.

CCR traffic is already "smooth" and voice quality will suffer from delay thus this traffic class will use a separate and smaller buffer with priority over the bursty buffer with priority over the bursty buffer for access upstream.

The resultant structure of the upstream buffers is illustrated in Figure 1; however, simple buffering is not enough on its own to smooth the traffic flow. If the output rate is significantly greater than the mean input rate, then the queue in the buffer will be nearly empty and the output will retain much of the burstiness of the input. The output must therefore be rate-controlled so as to create a traffic flow which comes close to emulating that of a CCR channel. However, if the output rate is too restricted then the buffer will fill up and may overflow; thus, a feedback mechanism is required which constrains the output flow sufficiently to maintain a fairly constant level in the buffer.

The size of the bursty traffic buffer is maintained between limits by the mechanisms shown in Figure 2. If the queue size falls below the lower limit then the output rate from the

buffer is incrementally reduced; similarly, if the size goes above the upper limit the output rate is increased. With small increments of change the output rate will change relatively slowly, hence creating a smooth flow of cells.

ITU recommendations provide for a 3-bit cell-type field in the header of each ATM cell and one of the codes in this field is for a congested indication. This indication is set by any switch or statistical-multiplexer in the path of a VC or Virtual Path (VP) when there are signs of the approach of congestion; usually when the buffer contents exceed a pre-set value. The intention is that persistence of the congested indication, detected at the destination User-Network Interface (UNI) (above or below the 'T' reference point depending upon implementation), will result in the return to the source of a congested-message.

The cell-type field also provides for identifying a resource-management (RM) cell which is transmitted over the return path of the related Virtual-Channel and carries the congested-message. In fact, RM cells are returned at regular intervals (e.g. every N cells received on the channel) whether or not a persistence of congested-indications has been detected.

An RM Cell received at the source may indicate one of three conditions of the upstream track which result in the following actions:

1. Congested: shifts the buffer limits (together) one increment up the buffer until the upper buffer margin is reached.

   Extends the period over which the bursty input is integrated.

   Temporarily reduces the output rate of the buffer (until it refills).

Increases the path delay.

2. Hold: maintains the present state.

3. Uncongested: shifts the buffer limits (together) one increment down the buffer until the lower buffer margin is reached.

Eventually restores the original state.

CLAIMS

1. A switched Asynchronous Transfer Mode (ATM) network comprising a plurality of switches and having at or adjacent to the input of the network a set of three first-in first-out (FIFO) buffers for receiving calls comprising ATM traffic, the buffers being for Constant Bit-Rate (CBR) traffic, Sustainable Cell-Rate (SCR) traffic and Available Bit-Rate (ABR) traffic forms of ATM traffic respectively, the output rates from the SCR and ABR buffers being controlled by increasing the output rate of a buffer by a small increment when the contents of the buffer exceed an upper specified value and reducing the output rate by a small increment when the contents of the buffer are less than a lower specified value.

2. A network as claimed in Claim 1, wherein cells in the CBR buffer have a first priority for egress, cells in the SCR buffer have a second priority for egress and cells in the ABR buffer have the lowest priority for egress.

3. A network as claimed in Claim 1 or 2, wherein each cell has in a header thereof a field which may be set by a switch to indicate the onset of a congested condition in the buffers and at the addressed destinations of the network Resource Management (RM) cells are periodically transmitted to the input, the RM cell carrying in the payload thereof information indicating when persistent receipt of cells carrying the indication of a congested condition is occurring and the receipt of RM cells at the input and carrying such information causing the lower and upper specified values to be moved jointly up the buffer until a limiting upper value is reached.

4. A network as claimed in Claim 3 wherein subsequent receipt of RM cells at the input not

carrying such information causing the lower and upper specified values to be lowered jointly in the buffer until a limiting lower value is reached.

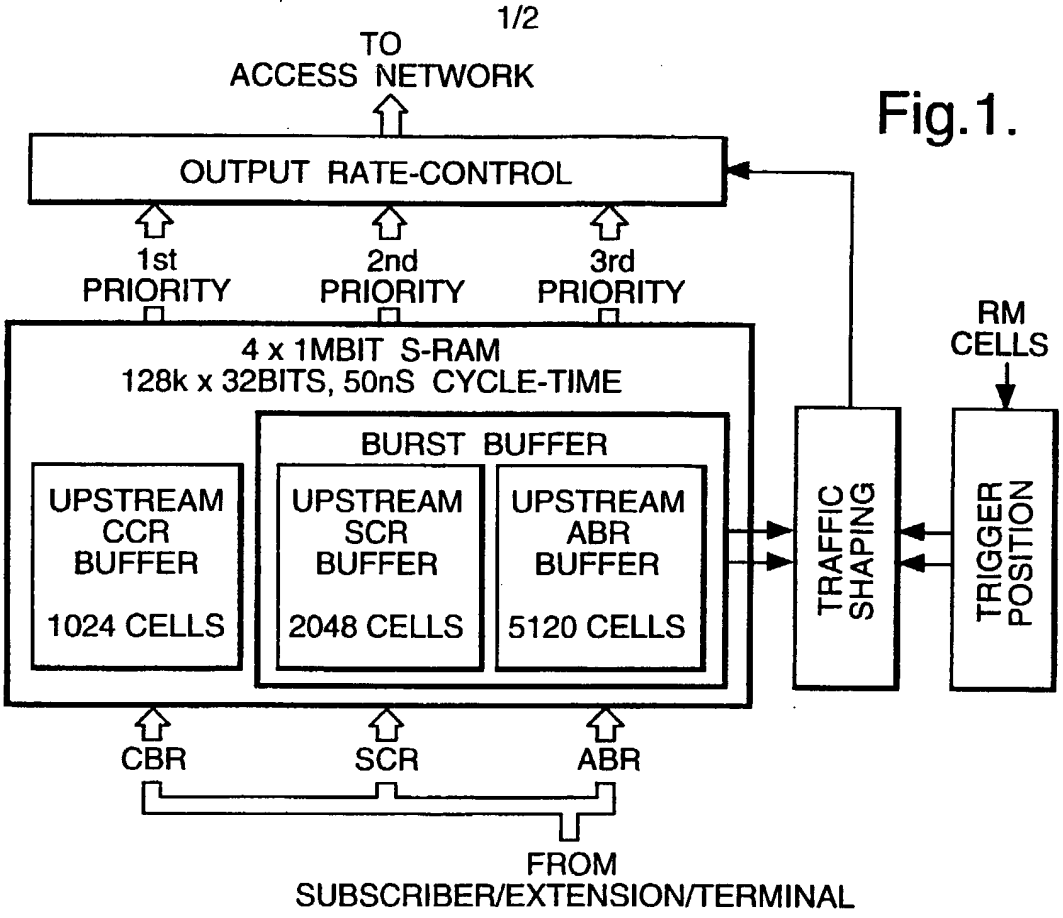
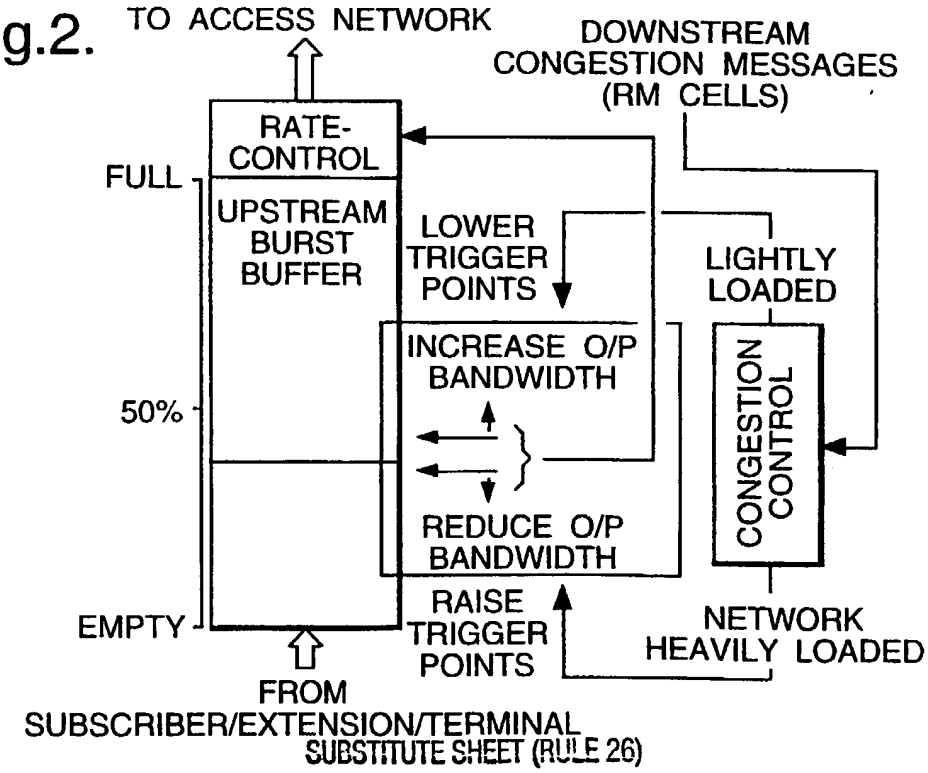

TO
ACCESS NETWORK
OUTPUT RATE-CONTROL
1st
PRIORITY
2nd
PRIORITY
3rd
PRIORITY
4 x 1MBIT S-RAM
128k x 32BITS, 50nS CYCLE-TIME
BURST BUFFER
UPSTREAM
CCR
BUFFER
1024 CELLS
UPSTREAM
SCR
BUFFER
2048 CELLS
UPSTREAM
ABR
BUFFER
5120 CELLS
TRAFFIC
SHAPING
RM
CELLS
TRIGGER
POSITION
CBR
SCR
ABR
FROM
SUBSCRIBER/EXTENSION/TERMINAL

Fig.1.

Fig.2.


TO ACCESS NETWORK
DOWNSTREAM
CONGESTION MESSAGES
(RM CELLS)
RATE-
CONTROL
FULL
UPSTREAM
BURST
BUFFER
LOWER
TRIGGER
POINTS
LIGHTLY
LOADED
INCREASE O/P
BANDWIDTH
50%
CONGESTION
CONTROL
REDUCE O/P
BANDWIDTH
EMPTY
RAISE
TRIGGER
POINTS
NETWORK
HEAVILY LOADED
FROM
SUBSCRIBER/EXTENSION/TERMINAL

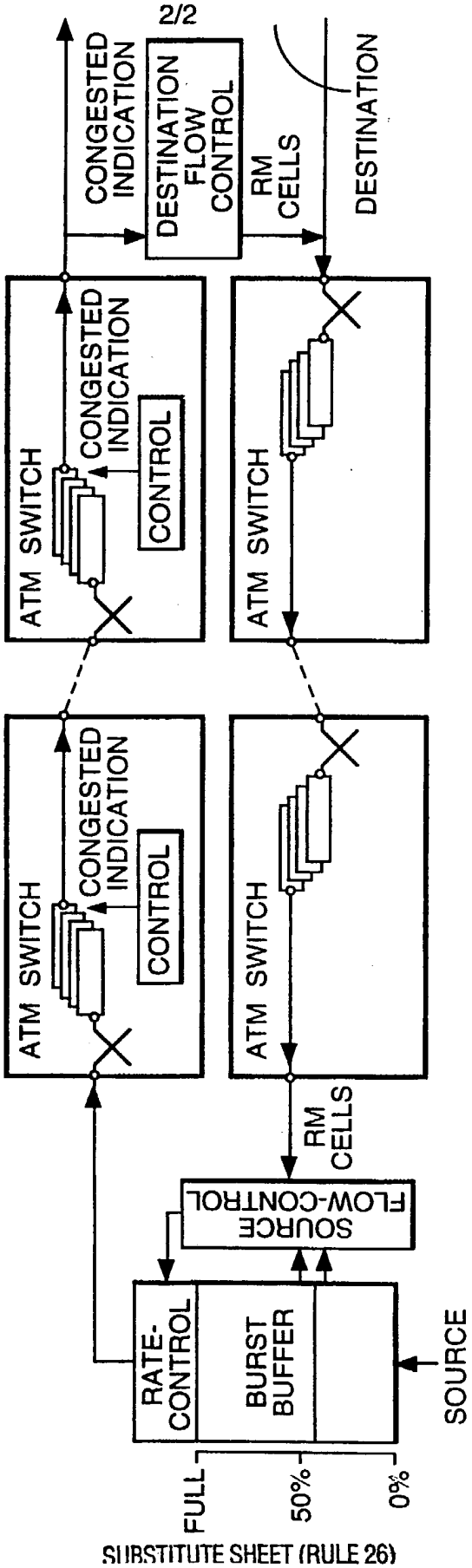

CONGESTED INDICATION
DESTINATION FLOW CONTROL
RM CELLS
DESTINATION
ATM SWITCH
CONGESTED INDICATION
CONTROL
ATM SWITCH
ATM SWITCH
CONGESTED INDICATION
CONTROL
ATM SWITCH
RM CELLS
SOURCE FLOW-CONTROL
RATE-CONTROL
BURST BUFFER
SOURCE
FULL
50%
0%

Fig.3.